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ABSTRACT

This paper discusses several important issues and concerns associated with the topic of technology education. These topics include: (1) the nature of technology education; (2) the technology and science argument; (3) technology education and general education; (4) technology as a holistic approach; and (5) technological literacy and general education. This discussion attempts to weave each of the above into a fabric for understanding, as well as practice for technology educators, as a needed component in general education. The discussion is based on the premise that there is a role for technology education in the general education framework and secondly, the vital role of technology education is establishing a holistic approach that provides a setting for the integration of the other general education subjects. (KR)

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# TECHNOLOGY EDUCATION -- A HOLISTIC APPROACH IN A GENERAL EDUCATION FRAMEWORK

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# TECHNOLOGY EDUCATION -- A HOLISTIC APPROACH IN A GENERAL EDUCATION FRAMEWORK

by

Dr. Donald Maley

There are several important issues and concerns associated with the topic. These would include:

- o The nature of technology education
- o The Technology and science argument
- o Technology education and general education
- o Technology a holistic approach
- o Technological literacy and general education

This discussion will attempt to weave each of the above into a fabric for understanding, as well as practice for technology educators, as a needed component in general education. It is based on the premise that there is a role for technology education in the general education framework and secondly, the vital role of technology education is establishing a holistic approach that provides a setting for the integration of the other general education subjects.

Such a discussion, if it is to go anywhere, must first of all start with the assumption that technology education can, or does, find a place in what may be termed general education. This assumption may be on weak academic ground if the past educational record of the schools is any kind of an indicator of the presence of the study of technology in our schools. This concern was brought into focus through a statement by Dr. Ernest Boyer in his book, The High School, in which he commented: "We were quite frankly disappointed that

none of the schools visited required a study of technology. More disturbing still is the current inclination to equate technology with computers ....." (p. 111) This statement by Boyer is quite revealing in an age so profoundly influenced by technology in all dimensions of human existence. However, there could be, and probably are, many high schools across this nation in which the study of technology was indeed a part of the educational experiences of many young people. The statement by Boyer addressed the issue of a study of technology not being required. This is without a doubt an accurate statement with respect to the findings of the study. The issue appears to be whether the study of technology was required and not to say or infer that it was not present or available to the students. The fact that no evidence of technology education as a required subject was found should send a strong and clear message to the profession.

However, it does raise a very important question regarding "general education" in an advanced technological society. In this respect, such a finding may be typical and symptomatic of an institution (our public schools) that suffers from a form of rigor mortis and a reluctance to change even in the face of enormous societal impact from technological developments that come in a never-ending stream. This might raise the question regarding the present general education offering as : "general education for what period?"

As one begins to examine the general education framework for our public secondary schools, there appears to be at least two different ways in which the construct takes place. The first and overwhelming framework centers around a series of courses required of students that supposedly provide the functional and cultural essentials for the individual as pre-requisites for graduation.

This series of courses generally consists of such subjects as English, mathematics, science, social studies, fine arts, and, in some states, foreign languages. When the question is raised about the apprent lack of presence or

any substantive amount of technology education, the response frequently turns to the disciplines of mathematics and science. However, this is a relatively uninformed and narrow perspective on technology that does not begin to approach any real or meaningful dimension of technology education.

This equating of science and mathematics as being technology education has been discussed in the National Science Foundation report titled Educating Americans for the 21st Century (Source Materials) (1983) as a "basic" in education and a part of the general literacy of all people.

> . . . In a sense, we are speaking of "basics" in education, and we are identifying the knowledge and understanding of technology as basic. Technological literacy is quite different from scientific literacy and mathematical literacy. An understanding of scientific and mathematical concepts doesn't automatically result in an understanding of technology. (p. 73)

## The Nature of Technology Education

In a discussion of "Technology: A New Liberal Art," Joseph C. Gies (1982) has delineated the difference between science and technology in the following comment.

> Technology is not to be confused with science. Science is what the universe, macrocosm and microcosm, consists of -- stars, planets, galaxies, cells, atoms, particles. Technology is tools, machines, power, instrumentation, processes, techniques. (p. 17)

The major points of difference between technology and science are in the nature of the item under discussion, the use toward which it is put, and who created it. Technology is the great multiplier. It is a means of extending the human's reach. It is a mechanical or physical advantage contrived by the human to extend his/her capability. It is the difference between a form of agriculture where one can barely raise enough crops to feed one person to that in which one person can raise enough food to feed hundreds of people.

Technology, according to the publication, Educating Americans for the 21st Century, (1983)

> . . . consists of the tools, devices, and techniques that have been created to implement ideas borne of science and engineering. Technology exists to manage and modify the physical and biological world in a constructive way. . . (p. 73)

The relationship of technology to science and mathematics is an issue that has had a variety of interpretations. The science community, as expressed through the National Science Foundation, makes strong ties and linkages between science, mathematics and technology.

A more comprehensive overview of the educational spectrum might establish technological linkages that would connect with most disciplines or areas of the school.

- Technology education is the only overreaching component of public education that provides, as well as demands, the high degree of inter-disciplinary involvement if understanding is the goal. Furthermore, the linkages and inter-disciplinary connections are significantly enhanced by the experiential nature of the instructional activities and strategies associated with technology education.
- Technology education has a strong historical component. It is, in fact, the thread of the fabric on which the great civilizations of the past, with all their many accomplishments, may be unraveled. This historical connection in humankind's transition from the cave to the skyscraper and into outer space is the great and revealing study of human ingenuity manifested through technological developments in a never-ending stream.
- Technology education has strong social and environmental studies linkages so essential to understanding, decision-making, and planning for the future.
- Technology education has strong interdisciplinary linkages with music, art, medicine and agriculture. It has been the element of possibility in each -- for each has achieved its present status on the basis of

technological intervention in the hands and minds of creative and ingenious humans.

- Technology education and its linkages with science and mathematics is in many ways the most obvious of the interdisciplinary connections. Yet in the minds of many there is the "hen and egg" propositional argument that fails to understand that much of the great scientific accomplishments of humankind -- from Newton's astronomical observation about the solar system to the setting of the human on the moon -- were indeed dependent on technological achievements all along the line.

The Technology and Science Argument

The whole relationship of science to technology has been a matter of considerable debate, even within the scientific community itself. The New York Times Large Type Weekly of August 13, 1984, contained a most revealing and insightful article titled "Genius or Technology for Science." It is a discussion of the way in which various groups and individuals view how science works. It is a new school of thought that places technology in a more prominent role that may in logic precede the great achievements of humankind.

> The new school lauds technology as an overlooked force in expanding the horizons of scientific knowledge.
>
> The rebellion was led by Derek J. DeSolla Price, an eminent science historian at Yale University. Shortly before his death last year, Dr. Price landed his most powerful blow in the campaign, arguing that science moves forward not so much through the insights of great men of genius as because of more mundane things like improved techniques and tools.
>
> The big breakthrough of the 17th century was not when Galileo first turned the telescope on the heavens, he argued in a lecture, but when improvements in lens-grinding techniques allowed eyeglass makers to construct the first telescope.
>
> "In short," Dr. Price concluded, "the scientific revolution, as we call it, was largely the improvement and invention and use of a series of instruments of revelation that expanded the reach of science in innumerable directions." (p. 29)
>
> . . . .

> Galileo's crowning glory, as set forth in traditional histories, was that in 1609 he was the first person to turn the newly invented telescope on the heavens to prove that the planets revolve around the Sun rather than the Earth. (p. 30)
>
> . . . .
>
> The real hero in the story, Dr. Price asserted, was the long evolution in the improvement of machinery for making eyeglasses. A key development was the invention of the glass lathe in the late 16th century, which made it possible to produce powerful concave lenses. Two of these were soon combined to produce crude telescopes . . . . (p. 31)
>
> . . . .
>
> Over the years, tools and technology themselves as a source of fundamental innovation -- rather than the other way around -- have largely been ignored by historians, philosophers and sociologists of science. Working scientists at times have alluded to the importance of tools, however. Early in the 19th century the chemist, Thomas Graham, observed, "It is curious how much the progress of science depends upon the invention and improvement of instruments." (p. 30)
>
> Dr. Price's most bitter attack on the conventional wisdom occurred when he delivered the prestigious George B. Sarton Memorial Lecture at the 1983 annual meeting of the American Association for the Advancement of Science. There he took his analysis one step further by saying that technology was in fact the wellspring of all scientific discovery. What was crucial in scientific history, he argued, was not people deducing great truths, but individuals playing with certain tools and techniques to see what happened. (p. 30)

The logic of Dr. Price is fundamental to understanding the relationship which exists between technology and science. It is a logic that appears to have eluded, almost by design, the role that technology has played in other highly accepted areas of the general education construct. As an example, the study of the arts as depicted through the grandeur of the Acropolis in Athens, the structures at Delphi, and the sheer magnificence of the Temple of Sounion. These great works of humankind find their place in the study of art and history as general education throughout the Western World. They are identified as the artistic products of creative and dedicated artists of another era.

Here again, the work of the designer or the artist would remain in their minds or on their paper as sketches of what might be, if it were not for that

enabling tool of technology which would provide the means for ideas to become fluted columns, ornamental frieze, or decorated cornice in the architectural design. The difference between ideas and reality is in many instances the available technology.

Some years ago I had the pleasure of spending an extended afternoon in the great Museum of Archeological History in Athens, Greece. The magnificence of the thousands of artistic objects in this great cultural repository caused one's eyes to bulge with awe and excitement as he/she passed from room to room and floor to floor. It was as if to walk among the gods and sages of the past. However, as a technologist, I was looking for something more than the great and beautiful works of art. I was searching for evidence of how it was possible in those ancient times for the people, the artisans and workers to produce those items. That dimension of the process obviously was not important, for it was only in very rare and minor instances in those great halls that one would see any display of the tools or means of technology that made them possible.

The great pyramids of Egypt and the coliseum of Rome will forever find their place in the accomplishments of humankind as monuments in the study of generations or civilizations long past. But search in vain, if you will, in most books of general education requirements, to see if one can learn how they were built -- i.e., how the grand designs of the architect or artist became a reality for their intended purpose and for future generations to immortalize.

These are, in essence, the same arguments that Dr. Price put forth for science. The only difference is the field of study. The same apriority position of technology can be set forth for the fields of medicine, agriculture, construction and engineering. The technology in a given field becomes the means of implementation of ideas through the guidance and work of humankind.

Thus, these few comments begin to set forth the rationale for the study of technology as a vital link in the progress of humankind in practically all forms of productivity. Further support for the role of technology education can be found in Roger Burlingame's Technology and Culture (1959) and Sherwood L. Washburn's discussion of "Tools and Human Evolution" in Culture and the Evolution of Man, edited by M.F. Ashley Montague (1962).

Technology Education and General Education

One model for the inclusion of Technology Education in the general education construct of the public school program would be to include it as another in the list of courses which all students would pursue in the process of their schooling. In its simplest form, such an arrangement would appear as follows:

Communication courses (English)

Mathematics courses

Science courses

Social Studies courses

Fine Arts courses

Technology courses

This model simply adds another series of courses to the existing ones. This concept of general education inclusion of technology education would be to add an additional cell (the technology cell) on to the present cellular curriculum consistency of the public schools. The principal argument for the study of technology in this model would be the importance of, and need for, the study of technology in the contemporary and future societies. The argument may well center around the issue of "technological literacy".

Perhaps what is needed is an examination of the content of the presently accepted general education courses through an examination of the relevance of the content for the present and future. Another approach might be to examine

the needs of the individual citizen in the latter part of the 20th Century. This latter direction would be a much more pragmatic approach to the issue of general education. Such an approach would not necessarily rule out the subjects of English, science, mathematics or social studies. But, it would raise the questions of: English for what?; science for what?; mathematics for what?; and social studies for what?

This "for what" scenario might well clarify some of the commonly expressed concerns that the so-called general education subjects have been developed and practiced out of the context for which general education is intended.

When we teach mathematics as if every student is going to be a mathematician, we have lost sight of the function of general education. It thus becomes highly specific in nature and eludes the very purpose it was intended to fulfill.

When we teach science as if every student is going to be a scientist, we commit the same error as stated above with mathematics. This point was made in a "Trends" article written by John Mattill, appearing in The Technology Review, in which he quotes prominent science educators and their reactions to the current science instruction in our schools.

> . . . Professor Morris H. Shamos, of New York University, suggests teaching, not science itself, but technology. Although high school students have traditionally been taught pure science, Shamos argues that it is too abstract to interest most of them -- and perhaps their teachers, too. Teenagers generally do not need to know about solutions, temperatures, neutrinos, or the mechanics of solids.
>
> . . . .
>
> For nonscience students, the teacher's "primary objective should be to make them feel comfortable with their surroundings," . . . Education should help students understand enough about the workings of modern technology "to have a sense of being in control -- to know the capabilities and limitations, and to appreciate the dangers.

The teaching of English as a vital form of communication, expression, and human extension can not be disputed as vital to the general education function. Yet, after twelve years of English in the elementary and secondary schools, the complaints about student inadequacies in this area are rampant. Here again,

perhaps the question is, "English for what?".

This leads to the concern for "general education" itself and the possibility that this requirement in our schools has a need for re-examination and perhaps some internal adjustment in keeping with the human needs of people living today.

It is in this analysis of the needs of persons in this era that the case for technology education as a vital component of the general education framework can be made. Such an analysis of the needs of the persons or citizens of today in these United States might be made in terms of the functions of a citizen in this time and place in history. Such functions would include the citizen's requirement to perform as:

1. a user of a vast array of technology,
2. a decision-maker -- both personal and as a citizen regarding technology,
3. a purchaser and consumer of a wide variety of technology,
4. a key element in the further use or development of technology,
5. a worker and wage earner in an increasingly technological workplace.

All of these call for a form of technological literacy that is unparalleled in the history of humankind. This is not a literacy that is restricted to certain groups or individuals. It is a literacy demanded of most people. Thus, the issue of need for technological education becomes a persuasive one. It is universal as well as highly individualistic in nature.

## Technology, a Holistic Approach

The preceding discussion presented a general education framework that included Technology Education as one more cell in the list of subject matter cells the student would study. This, at the very least, would be a step forward in school requirements for an advanced technological society. However, in view of what we know about the nature of learning, and the nature of subject matter, this cellular, compartmentalized subject matter isolationism is not

appropriate nor very efficient in the learning process.

The alternative to the subject matter isolationism and cellular framework of the modern school, is to provide one or more subject areas in the school program where there can be a holistic, integrated form of education. It would be subject areas where the student could put the elements of the curriculum into a working relationship for greater understanding and meaning, as well as application in the world of reality.

Technology Education is such an area. There are no subject matter fields in the present school that can not find meaningful integration in the area of Technology Education. The various reports coming out of the National Science Foundation continually stress the internal linkage of science, mathematics and technology. But the emphasis on holistic learning and integrated subject matter through Technology Education must extend into other disciplines and areas of study other than mathematics and science.

This point was made by Dr. Ernest Boyer after viewing a series of panels illustrating the integration of mathematics and science for greater understanding of early technological developments currently being constructed by students in the public schools. His advice was to go beyond mathematics and science and to include such dimensions as societal impact and environmental impact of these technologies being studied by the children.

The advocated general education framework would not cause serious disruption of the present curricular and subject matter structure. The principal innovation would be to constitute an experiential laboratory or series of experiential laboratories dedicated to the study of technology. It would be a place in the school program where the student could put it all together. It would be a school program based on the application of knowledge and the establishing of linkages with the fields of mathematics, science, history, economics, communications, health, art, music, social and environmental studies.

Such a role could very appropriately be an extension of the current cellular, abstract, and theoretical content into an extension of application, verification, and use through effective programs in technology education. The value of the interface of mathematics and science in the study of technology is expressed in a comment found in the National Science Foundation (1983) report dealing with Educating Americans for the 21st Century.

> Real problems - the products of technology - provide numerous exciting applications of mathematics and science . . . When technology is used to introduce scientific thinking, it will appeal to the student as more interesting and relevant, and hence be a motivator. The mathematics and science education now offered to our young people could be greatly enriched if we were to incorporate a technological content. (p. 73)

The major issues here are real problems, products of technology, and using technology as a motivator, as well as a stimulator for the study of mathematics and science.

## Technological Literacy and General Education

A prime factor in the discussion of technology education in a general education framework is the identification of a major thrust that is within the capability of the subject or content area. Technological literacy is such a thrust that can and must be the central drive of Industrial Arts/Technology Education.

- It is a thrust that is vital to all people living in present and future societies.
- It is an area of understanding that has not been adequately dealt with in the present general education framework.
- It is an area eminently suited to Industrial Arts/Technology Education in theory and practice.

"Technological literacy" takes many forms and perspectives depending upon who is speaking or writing. The National Science Board Commission on Precollege

Education in Mathematics, Science and Technology, in their publication, Educating Americans for the 21st Century (1983), presented the following points in a rational for learning technology at the precollege level:

1. People must know about technology in order to improve the quality of many personal and professional technology-based decisions.

2. Technological literacy prepares individuals for intelligent participation as informed citizens in the transition from an industrialized society to a post-industrialized service and information age.

3. Technological literacy will encourage greater participation by individuals in shaping public policy, which often involves the use of sophisticated technology. It will tend to encourage civic responsibility and overcome voter torpidity, which can arise out of a lack of understanding of new technologies.

The intent is to strengthen young people early with the awareness and flexibility that comes with technological literacy. (p. 74)

As one attempts to examine the interface between technology and the disciplines of mathematics and science as a fundamental curriculum framework, it is important that one of the major goals to be achieved is what has been termed technological literacy. This raises the issue of what is it that the school can do to develop in the citizenry a reasonable degree of technological literacy.

The previously cited National Science Foundation report (1983) lists five important kinds of understanding that can contribute significantly to technological literacy. These five understandings include:

1. the historical role of technology in human development,
2. the relationship between technological decisions and human values,
3. the benefits and risks of choosing technologies,
4. the changes occurring in current technology, and
5. an understanding of technology assessment as a method for influencing the choice of future technologies. (p. 74)

These five areas of contribution to technological literacy provide a comprehensive prescription of understandings to be achieved. These five areas are fully and appropriately within the realm of good and effective Industrial Arts/Technology Education programs. The following is a brief sketch of a very few potentials for Industrial Arts/Technological Education in the implementation of these areas of technological literacy. It is emphasized that there should be a hands-on, experiential involvement in the activities presented.

1. The historical role of technology in human development.

   Industrial Arts Technology Education Implementation Activities:

   The Anthropological Unit Approach (project, report, seminar)

   a. The development of tools and machines and their contribution to the growth of civilization.

      Typical problems and projects -- trebuchet, Archimedes screw, plow, loom, cotton gin, camera, winch, pulley, block and tackle, bow and arrow, drill, catapult, forge, cam, gear, clock, etc.

   b. The development of power and energy and their contribution to the growth of civilization.

      Typical problem and project selections -- windmill, water wheel, turbine, Hero's steam engine, Newcomen's steam engine, Watt's steam engine, jet engine, electric generator, electric motor, winch, block and tackle, pulley, sails.

   c. The development of communications and transportation and their contributions to the growth of civilization.

      Typical problem and project selections -- wheel, automobile, ox cart, ship, telegraph, semaphore, telphone, boats, airplane, bridges, printing, printing press, writing, steamboat, balloon, papermaking, roads, railroads, pony express, lighthouse, canal, etc.

2. The relationship between technological decisions and human values.

A contemporary community planning or city reconstruction activity using the group project or unit project approach. (projects, reports, seminars, analyses)

a. Community planning or reconstruction group projects.

Typical group projects -- local community redesign, transportation systems design, housing developments, park and recreational development, emergency planning, etc.

b. Community planning using the unit project approach.

Typical unit topics or problems might include:

(1) Transportation systems for the community.

This may involve individual student projects in such areas as -- monorail, subway, elevated highways, tube transportation, express highways, airport, heliport, waterways, highway design, walkways, peoplemovers, etc.

(2) Housing systems for the community.

This may include individual student projects in such areas as -- condominiums, high rise, lower income housing, underground, bomb shelters, shopping centers, business and industry complexes, etc. (individual student variations in each)

(3) Educational and recreational systems for the community.

This may include individual student projects in such areas as -- centralized park, decentralized park, amusement park, theatre, concert facilities, playing fields, swimming pools, water recreation, kindergartens, nursery schools, industry-nursery schools, elementary schools, secondary schools, community colleges, sports arena, music hall, museum, art gallery, etc.

(4) Industrial and business planning for the community.

This may include individual student projects in such areas as -- types of industries, location of industries, transportation industries, living units and industrial locations, living units and business locations, environmental impacts of industries, waste disposal, hazardous material transportation, etc.

3. The benefits and risks of choosing technologies.

A contemporary and futuristic series of unit approaches designed to explore the alternatives to various technological systems. (projects, reports, analyses, seminars)

(a) The technological alternatives in energy development

(b) The technological alternatives to trash and waste disposal

(c) The technological alternatives in housing developments

(d) The technological alternatives in water development and utilization

(e) The technological alternatives in communications development and use

(f) The technological alternatives in transportation development and use

(g) The technological alternatives in production processes

(h) The technological alternatives in pollution control

4. The changes occurring in current technology.

A contemporary and futuristic unit instructional approach that would take a series of areas of current technological developments and examine what is happening in each.

Activities: The unit approach

Individual reports

Analyses of presentations

Seminars

Inter-disciplinary discussions

This could be accomplished through units of study dealing in such topical areas as:

(1) Modern manufacturing processes

- lasers
- robots
- machining
- materials handling
- quality control
- automation
- numerical control
- computer controlled
- in-space manufacturing
- under-sea manufacturing
- etc.

(2) Modern transportation systems

- vertical takeoff planes
- monorail systems
- people movers
- rail transportation
- ground effects machines
- internal combustion
- solar powered units
- tube transportation
- elevated transportation
- water and submerged transportation

Other instructional units, without mentioning specific items, might include:

(3) Modern and futuristic construction processes

(4) Modern and futuristic communications processes

(5) Modern and futuristic energy development processes

(6) Modern and futuristic navigational processes

(7) Modern and futuristic environmental control processes

(8) Modern and futuristic shopping and merchandising processes

5. <u>An understanding of technology assessment as a method of influencing the choices of future technologies</u>.

Technological assessment is a vital and imperative process that can provide some degree of rationale for the promotion or development of a given technology or technological system. It is a reaction to the logic

or practice of "just letting things happen." How this element of technological assessment is dealt with in our schools is addressed in the following comment from the National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983).

> Students must be prepared to understand technological innovation, the productivity of technology, the impact of the products of technology on the quality of life, and the need for critical evaluation of societal matters involving the consequences of technology. (p. 44)

The impact on the quality of life and societal matters by technology become serious concerns related to the need for technological assessment.

Boyer (1983) commented in a similar manner in his concern for the study of technology.

> All students should study technology: the history of man's use of tools, how science and technology have been joined, and the ethical and social issues technology has raised. (p. 304)

The dimensions of technology assessment in the Industrial Arts/Technology Education program can assume numerous directions as well as levels of inquiry. Some of these could be related to the following topics or categories.

- environmental impact
- health and hazard efforts
- ethical implications
- social issues raised
- use of finite resources
- impact on the common good
- resultant waste and disruption
- impact on living standards
- whose interests are being served
- proven worth of a technology
- technological alternatives
- etc.

Each of the above is a discussion or topical areas around which inquiry and discussion can be conducted with respect to the construction and experiential activities carried out by the students. This also could be with respect to the technologies dealt with in the earlier parts of this discussion of technological literacy.

Post Script

The place and relevance of Industrial Arts/Technology Education in the present technological society is beyond reasonable question. The issues center around the extent to which this area of study can move away from a craft and technic domination to a technology education emphasis that provides a form of education designed for all citizens in a democracy. The principal challenge is one of change for the profession and to communicate effectively to attain a change in attitudes among the decision-makers in our schools at all levels.

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